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Farm work, home work and international productivity differences

Douglas Gollin [a], Stephen L. Parente [b], Richard Rogerson [c,*]

[a] *Fernald House, Williams College, Williamstown, MA 01267, USA*
[b] *University of Illinois, 1407 W. Gregory Drive, Urbana, IL 61801, USA*
[c] *Department of Economics, College of Business, Arizona State University, Tempe, AZ 85287, USA*

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Abstract

Agriculture's share of economic activity is known to vary inversely with a country's level of development. This paper examines whether extensions of the neoclassical growth model can account for some important sectoral patterns observed in a current cross section of countries and in the time series data for currently rich countries. We find that a straightforward agricultural extension of the neoclassical growth model fails to account for important aspects of the cross-country data. We then introduce a version of the growth model with home production, and we show that this model performs much better.

1. Introduction

Economists have long recognized that agriculture's share of economic activity varies inversely with the level of output. This is true both across countries and over time within a given country. Development economists have traditionally viewed the process of structural transformation—including the relative decline of the agricultural sector—as an important feature of the development process.[1] In contrast, modern growth theorists

* Corresponding author.
E-mail addresses: dgollin@williams.edu (D. Gollin), parente@uiuc.edu (S.L. Parente), richard.rogerson@asu.edu (R. Rogerson).

[1] The relevant literature from development economics on structural change is too large to summarize, but key works dealing with the role of agriculture in the process of economic growth include: Johnston and Mellor (1961),

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have tended to abstract from sectoral issues in their examination of international income differences. A major branch of recent research in this area uses one-sector versions of the neoclassical growth model to examine the impact of various policy distortions on steady-state income levels. (Examples include: Chari et al., 1996; Parente and Prescott, 1994; Prescott, 1998; and Restuccia and Urrutia, 2001.) A general finding of this research is that such models can plausibly account for the huge observed disparity in international incomes provided that the combined share of tangible and intangible capital in income is around two-thirds.

The purpose of this paper is to determine whether such models can also account for the sectoral patterns present in both the cross section of countries and the time series of the currently rich countries. To accomplish this we consider an extension of the neoclassical growth model to include an agricultural sector and assess the quantitative implications of the theory for both aggregate and sectoral patterns. We believe that this provides an additional check on these theories while also offering a careful investigation of the claim—central to traditional development economics—that sectoral differences are critical to understanding international income disparities.

Our analysis begins with a straightforward extension of the neoclassical growth model to include an agricultural sector. Following the literature, we then consider policy differences across countries that serve to increase the cost of capital. We find that the model fails to replicate a key feature of the data first documented by Kuznets (1971) for a small set of countries and here for a larger set, namely, the enormous cross-country disparity in *relative* productivities of agricultural and non-agricultural sectors. This failure exists whether we consider distortions that affect the agriculture and non-agriculture sectors equally or unequally.

This failure leads us to follow Parente et al. (2000) and extend the standard growth model to incorporate Becker's model of home production. We deviate from Parente et al. by incorporating spatial heterogeneity into our model so that home production possibilities differ between rural and urban regions. As in Parente et al., distortions that discourage capital accumulation move resources out of market activity and into household production. In our model, however, there is an additional effect. Namely, these distortions induce people to stay in the rural area, where they devote much of their time to home production relative to the urban area. As a result, marketed agricultural output per worker is lower in distorted (poor) economies than in undistorted (rich) economies. To assess our theory we restrict the model's parameters to roughly match the US observations over the 1870–1990 period and then explore the consequences of policy differences for cross country differences in income, sectoral compositions, and sectoral productivity. We find that the home production model can account for most of the sectoral differences observed across countries as well as the secular changes in the United States over the 1870–1990 period.

Fei and Ranis (1964), Schultz (1964), Lewis (1955), Kuznets (1966), Chenery and Syrquin (1975), Johnston and Kilby (1975), Hayami and Ruttan (1985), Mellor (1986), Timmer (1988), and Syrquin (1988). A key debate in this literature is whether agriculture diminishes in importance because it has low inherent potential for growth (e.g., Fei and Ranis, 1964; Lewis, 1955) or because agricultural growth in some way stimulates non-agricultural sectors of the economy (e.g., Mellor, 1986).

As with the home production story told by Parente et al. (2000), our model predicts that measured output differences overstate true differences. For this reason, we compare welfare between distorted and undistorted economies. Despite there being more unmeasured output in the distorted economy, the welfare difference between rich and poor countries is still large.

We certainly are not the first to extend the neoclassical growth model to include an agricultural sector. An early literature dating to Uzawa (1961, 1963), Takayama (1963) and Inada (1963) explored two-sector growth models that could reasonably be interpreted as representing an agricultural sector and a non-agricultural sector. More recently, Echevarria (1995, 1997) and Kongsamut et al. (1997) have examined the secular decline in agriculture's importance in the currently rich, industrialized nations. These papers have not, however, sought to explain the current cross-country differences in agriculture's share of economic activity. In these papers, only initial capital stocks differ across countries, so that all the cross-sectional observations correspond to different points along the same equilibrium path. As we document, this view is inconsistent with the data.

There are a number of other dynamic general equilibrium models that likewise include an agricultural sector. Glomm (1992), Matsuyama (1992), and Goodfriend and McDermott (1995) all take an endogenous growth approach. Laitner (2000) focuses on differences in savings patterns across countries. His model conforms to Engels's Law, but the dynamics of his model are such that there are extended time periods during which only the agricultural sector is operating. Caselli and Coleman (2001) focus on a fixed cost associated with the acquisition of human capital in order to account for the secular decline of agriculture in the United States and the associated convergence in incomes between northern and southern states.

Our paper is organized as follows. Section 2 documents the current sectoral differences across countries and within countries across points in time. Section 3, by way of background, reviews the standard neoclassical growth model. Section 4 analyzes the standard neoclassical growth model extended to include an agriculture sector. Section 5 analyzes the home production extension of this model with an agricultural sector. Section 6 concludes the paper.

2. Some development facts

This section documents some key sectoral aspects of the development process. We begin with two well-known facts. The first is that in a cross section of countries, the agricultural sector is relatively larger in poorer countries, whether measured in terms of outputs or inputs. Figure 1 plots agriculture's share of GDP against real GDP per capita, using 1990 data from the World Bank's *Social Indicators of Development* and Penn World Tables (PWT 5.6), while Fig. 2 plots agriculture's share of total employment against real GDP per capita, using 1990 data from the United Nations *Human Development Report 1997* and PWT 5.6.[2] The slope of the trend line fit through the scatter plot in Fig. 1 is -0.094

[2] The World Bank's Social Indicators of Development report agriculture's share of GDP in 1990 for 150 countries in the world. For six more countries, we were able to obtain data on agriculture's share from the 1997

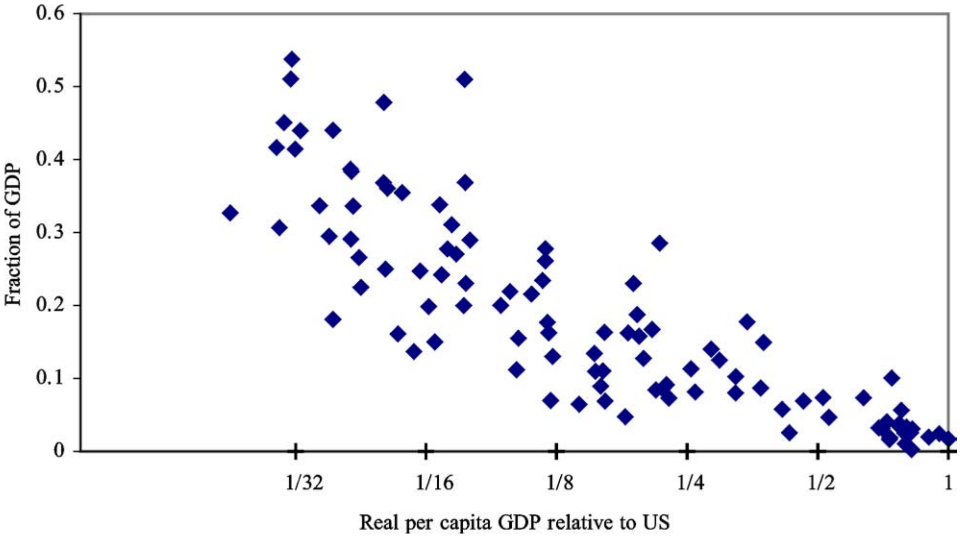

Fig. 1. Fraction of GPD in agriculture, 1990 cross section.

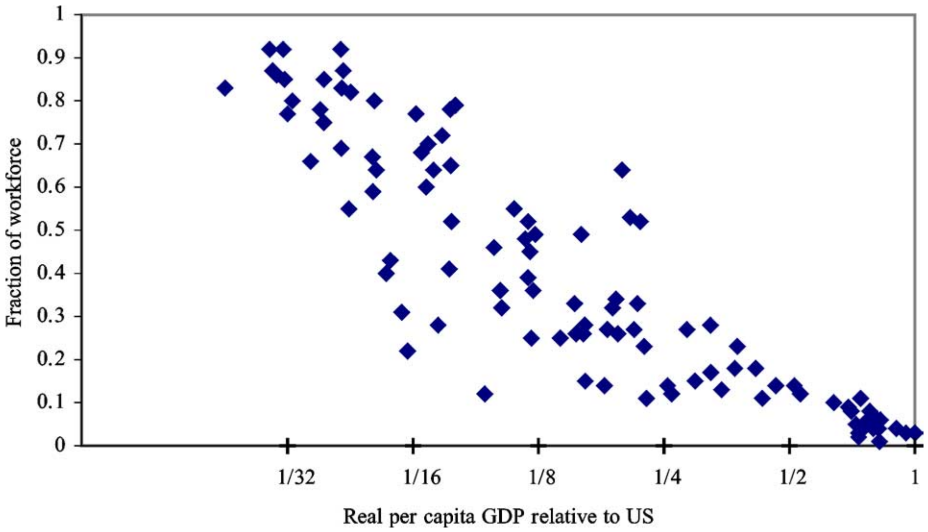

Fig. 2. Employment in agriculture as fraction of workforce, 1990 cross section.

while the slope of the trend line fit through the scatter plot in Fig. 2 is -0.20. The poorest countries have as much as 50 percent of GDP comprised of agriculture and as much as 70

United Nations *Human Development Report,* and for the United States we used data from the 1997 *Economic Report to the President.* We then used all of these countries for which 1990 data on real per capita GDP were available in the Penn World Tables v. 5.6, leaving us with a total of 102 countries.

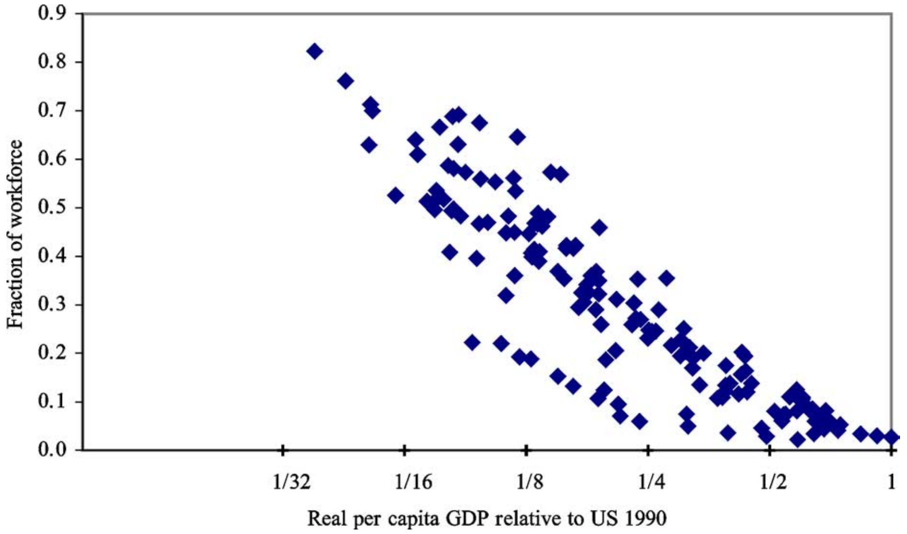

Fig. 3. Employment in agriculture as fraction of workforce, time series data for 15 industrial countries.

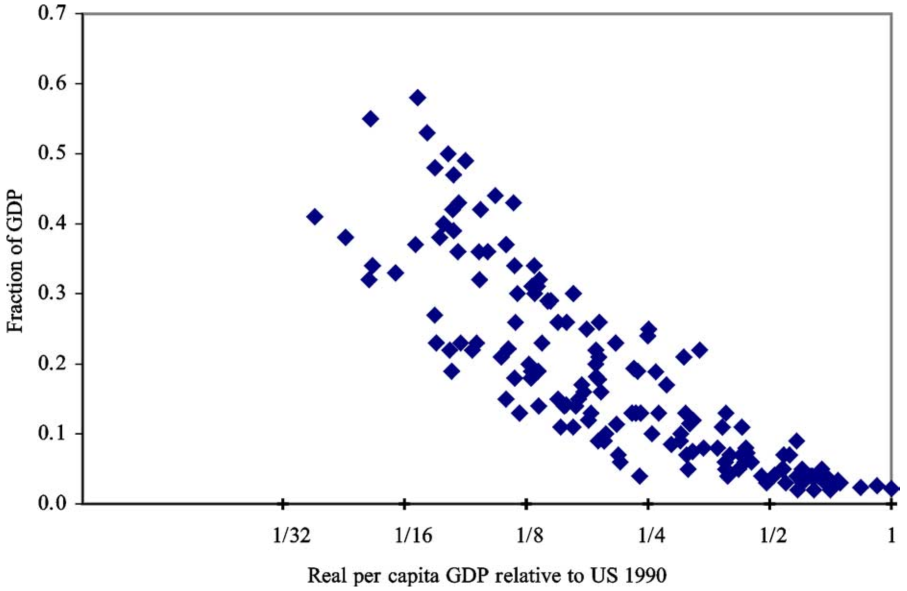

Fig. 4. Agriculture share of GDP, time series data for 15 industrial countries.

percent of employment in this activity. In the rich countries, these two shares are less than 10 percent of the totals.

The second well-documented fact is from time series data: the relative size of the agriculture sector both in terms of output and employment declines as an economy develops. This is documented in Figs. 3 and 4 using pooled time series data going back

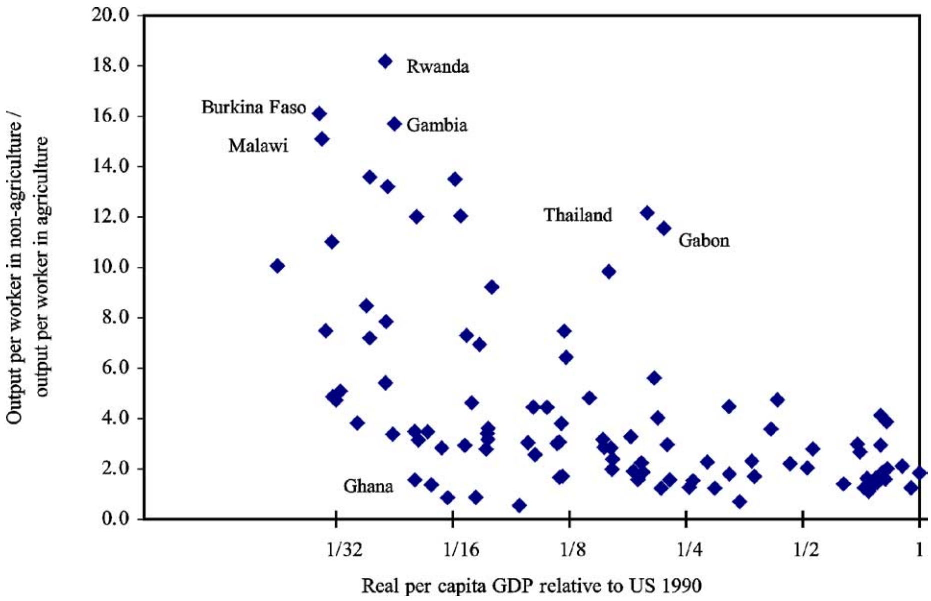

Fig. 5. Relative productivity in non-agriculture, by real per capita GDP, 1990 cross section data.

over two centuries for a set of 15 currently rich countries. In these figures the output and employment shares are plotted against each country's per capita GDP relative to the 1985 US level.[3] Looking at Fig. 4, for example, agriculture's share of total employment was about 50 percent in France in the mid 19th century, and about 50 percent in Italy as late as 1920. During the 20th century, however, these employment shares fell dramatically so that in 1990 they stood at no more than 10 percent in any currently rich country and as little as 2 percent in some countries.

The third fact is not as well known, though it is documented in Kuznets (1971) for a smaller set of countries and an earlier time period. Using the data on agriculture's share of GDP and employment, we compute a measure of output per worker in non-agriculture relative to agriculture. Figure 5 displays these relative productivity differences plotted against real GDP per capita for each of the countries in our sample. A striking pattern emerges—non-agricultural productivity in poor countries is far higher than agricultural productivity, often by a factor of 10 or more. By contrast, in the rich countries this ratio is typically less than 2. A regression of relative productivity of non-agriculture to agriculture on a constant and log of real GDP per capita yields a slope of -1.9.

It is important to note that these productivity measures are based on domestic relative prices. A number of studies have attempted to determine the extent to which differences in

[3] Data on employment shares and GDP shares in agriculture are taken from Mitchell (1992, pp. 912–917), Kurian (1994, pp. 93–94), Mitchell (1993, pp. 775–777), and Mitchell (1995, pp. 1027–1031). Data on real per capita GDP are taken from Penn World Tables, v. 5.6, for the available years of coverage; historical data are taken from Maddison (1995, pp. 194–206).

domestic relative prices explain these relative productivity differences. One set of studies, including Rao (1993) and Hayami and Ruttan (1985), finds the differences in relative productivities to be at least as large when PPP comparisons are made.[4] Another set of studies, including Kuznets (1971), Krueger et al. (1992), Schiff and Valdés (1992), and Bautista and Valdés (1993), finds these differences in relative productivities to be smaller on account of agricultural products being systematically under priced in poor countries by as much 40–50 percent. Whichever view we take of relative prices, it is clear that the cross-country differences in relative productivity are at least as large as differences in measured per capita output.

This striking difference between today's rich and poor countries leads us to examine the time series data to see whether such large relative productivity differences existed in the rich countries a century or so ago when they were as poor as today's poor countries. Although we do not have time series data for currently rich countries that covers the range of GDP per capita in the cross section, the available data suggests that relative productivity differences in the time series for individual countries are significantly smaller than differences in the 1990 cross section. Figure 6 plots the time series data for the United States, United Kingdom, and Canada, along with the 1990 cross section data on relative sectoral productivity against GDP per capita.[5] For the United Kingdom and Canada relative productivity has been nearly constant over time and close to one. This is essentially the case for almost all the currently rich countries. The one exception is the United States, which experienced a fairly large drop in this ratio between 1870 and 1900 from 4.3 to 2, but thereafter maintained a more or less constant ratio of 2.[6] As the figure clearly shows, a large number of today's poor countries are far away from the path followed in the past by today's rich countries. A similar finding appears in Kuznets (1971) for a smaller sample of countries.

The data analysis leads to several obvious questions. Why are relative productivity differences in today's poor countries so much larger than was the case for today's rich countries a century ago, when they had comparable incomes? Why are agricultural workers in the poorest countries apparently so unproductive? And why is there not greater

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[4] The Prasada Rao PPP-adjusted data (pp. 135–136, Table 7.3) show that agricultural output per worker in the highest-productivity country (New Zealand) is greater than the comparable figure for the lowest-productivity country (Mozambique) by a factor of 244. The ratio of average productivity in the five highest productivity countries to the average productivity in the five lowest is 139.3! Hayami and Ruttan (1985) also find differences in agricultural output per worker based on PPP measurements to be at least as large than differences in aggregate output per worker. In the 1960 cross section they find factor differences in agricultural output per worker between the top five and bottom five countries to be about 30, but in the 1980 cross section the factor difference is close to 50.

[5] Data on agriculture's shares of employment and output for the United Kingdom and Canada are taken from Mitchell (1992, 1993); those for the United States are taken from the US Department of Commerce's (1975) *Historical Statistics of the United States*, and from Kurian (1994) for more recent years. Estimates of real per capita GDP are taken from Maddison (1995) and PWT 5.6.

[6] Alston and Hatton (1991) actually suggest that the ratio of 2 for the United States is an artifact of regional productivity differences and agriculture being concentrated in the South. They show that once one corrects for non-cash payments to agricultural workers, there are no differences in agricultural and manufacturing wages within US regions.

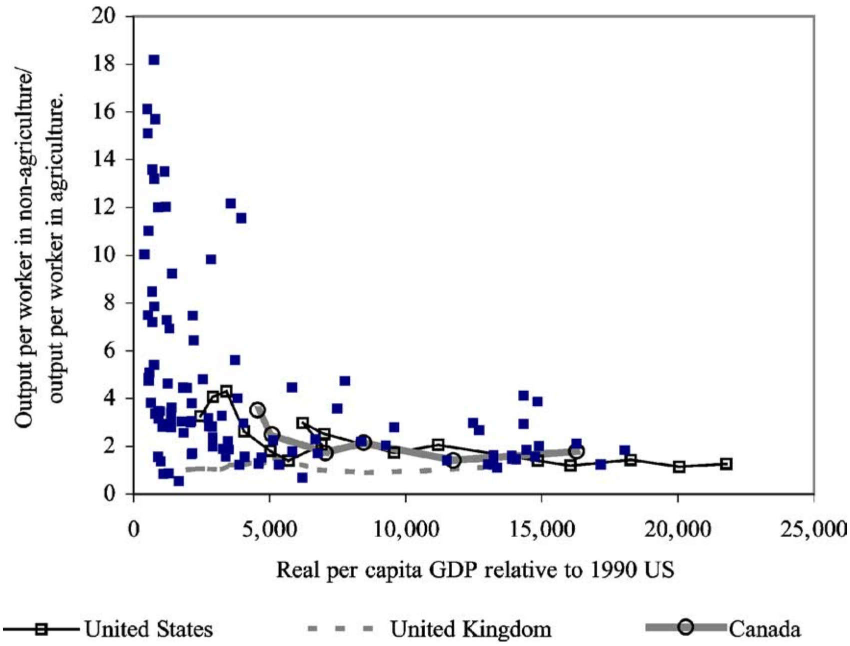

Fig. 6. Non-agricultural productivity relative to agricultural productivity—time series contrasted with 1990 cross section.

movement of labor out of agriculture in developing countries? The rest of the paper attempts to answer these questions.

3. Background

Recent efforts to account for international income differences within the neoclassical growth model have examined the consequences of cross-country differences in government policies for steady-state income. Two classes of policies have been studied: those that serve to raise the cost of investment goods relative to consumption goods and those that serve to decrease total factor productivity.[7] A brief overview of these efforts is instructive for our analysis.

The standard one-sector neoclassical growth model assumes a representative infinitely lived household with preferences given by

$$\sum_{t=0}^{\infty} \beta^t \log(C_t)$$

[7] Empirical evidence suggests that both of these channels are relevant. Jones (1994) presents evidence that the relative price of equipment is negatively correlated with GDP per capita, and Hall and Jones (1999) present evidence that measured TFP is positively correlated with GDP per capita. See also Restuccia and Urrutia (2001) and Collins and Williamson (1999) for evidence on the price of capital.

where $0 < \beta < 1$ is the discount factor and C_t is consumption in period t. The household is endowed with the economy's initial capital stock, K_0, and one unit of time in each period. A constant returns to scale technology produces output (Y_t) using capital (K_t) and labor (N_t) according to:

$$Y_t = AK_t^{\theta}\big[(1+\gamma)^t N_t\big]^{1-\theta},$$

where γ is the rate of exogenous technological change and A is a TFP parameter that summarizes the effects of government policies on a country's output per unit of the composite input. Feasibility requires that $C_t + X_t \leqslant Y_t$, where X_t is investment in period t. Capital evolves according to $K_{t+1} = (1-\delta)K_t + X_t/\pi$, where δ is the depreciation rate and $\pi \geqslant 1$ summarizes the effect of country-specific policies that increase the cost of investment relative to consumption. Following this literature, we refer to π as the barrier to capital accumulation.[8]

In assessing the consequences of differences in TFP or barriers to capital accumulation for differences in output, values for A and π can be normalized to one for the US economy without loss of generality. If another country has polices that yield TFP parameter A and barrier π it is easy to show that steady state output of the United States relative to this country is given by $A^{-1/(1-\theta)}\pi^{\theta/(1-\theta)}$.

This theory can generate large differences in output per capita given appropriate combinations of values for A, π, and θ. A number of researchers (see e.g., Prescott, 1998; Parente and Prescott, 2000) have argued that a value of two thirds for the share parameter θ is reasonable. This argument is based on a broad interpretation of capital that encompasses both tangible and intangible varieties. In what follows we adopt this parameterization and interpretation of capital.

4. The neoclassical growth model with agriculture

In this section we extend the standard neoclassical growth model to explicitly incorporate an agricultural sector, and ask whether it can account for the sectoral development facts described previously if policy distortions are present. The numeraire for this economy is the manufactured good.

4.1. Model economy

Instantaneous utility is now defined over two consumption goods. To account for the secular decline in agriculture's share of economic activity we adopt a functional form for preferences of the Stone–Geary variety. The discounted stream of utility is thus

$$\sum_{t=0}^{\infty} \beta^t\big[\log(C_t) + \phi\log(a_t - \bar{a})\big], \tag{1}$$

[8] While it is clearly important to understand how specific policies are mapped into A and π, we think this reduced-form approach serves to better highlight the key elements of our subsequent analysis. As noted above, we do not adhere to a literal interpretation of π as a policy distortion; the variable could equally well reflect a variety of institutional differences across economies.

where ϕ is a preference parameter, a_t is consumption of the agricultural good, C_t is consumption of the manufactured good, and $\bar{a} > 0$ is the subsistence term.[9]

The agricultural sector produces output (Y_{at}) using capital (K_{at}) and labor (N_{at}) as inputs according to the Cobb–Douglas technology:[10]

$$Y_{at} = A_a K_{at}^{\theta_a} \big[(1+\gamma)^t N_{at}\big]^{1-\theta_a}. \tag{2}$$

The manufacturing sector produces output (Y_{mt}) using capital (K_{mt}) and labor (N_{mt}) as inputs according to the Cobb–Douglas technology:

$$Y_{mt} = A_m K_{mt}^{\theta_m} \big[(1+\gamma)^t N_{mt}\big]^{1-\theta m}. \tag{3}$$

As we note later in this section, the assumption of Cobb–Douglas production functions has important substantive consequences for our analysis.[11] In addition to being a natural starting point for an analysis of this sort, this assumption is supported by empirical work. (See, for example, the cross-country analysis of Hayami and Ruttan, 1985.)

Output from the manufacturing sector can be used for consumption or to augment the two capital stocks. The manufacturing resource constraint is thus, $C_t + X_{mt} + X_{at} \leqslant Y_{mt}$. Output from the agriculture sector can only be used for consumption so the agriculture resource constraint is simply $a_t \leqslant Y_{at}$. Capital is sector-specific, so the laws of motion for the two stocks of capital in the economy are:

$$K_{mt+1} = (1-\delta)K_{mt} + X_{mt}/\pi_m, \tag{4}$$

$$K_{at+1} = (1-\delta)K_{at} + X_{at}/\pi_a. \tag{5}$$

For simplicity we assume that both capital stocks depreciate at a common rate; this restriction is not important to our findings. Given the sectoral patterns documented earlier, it seems potentially important to allow for policies that may differ across sectors, so we do allow policy to have differential effects on the accumulation of each capital stock through sector specific barriers π_a and π_m.

The household is endowed with one unit of time in each period, which it allocates between working in the manufacturing sector and working in the agricultural sector, and with the economy's initial capital stocks, K_{a0} and K_{m0}.

4.2. *Quantitative findings*

It is not necessary to calibrate the model to determine whether it can account for the relative sectoral differences observed across countries. It cannot. The main problem is that the model predicts that relative productivity is the same across countries regardless

[9] Following a longstanding convention in the literature, we refer to the non-agricultural sector as the *manufacturing sector*, although in our empirical work we will interpret this sector to include manufacturing activity as well as other industrial activities and services.

[10] We abstract from land as a fixed factor in agriculture. Adding land to the model does not affect our main quantitative findings.

[11] Note that we assume here that exogenous technological change occurs at the same rate in the two sectors. This assumption is motivated by the lack of any discernible trend in the relative price of agriculture to non-agriculture goods in the United States over the last 100 years (see Kongsamut et al., 1997).

of policy differences reflected in TFP or barriers to capital accumulation.[12] The reason for this is as follows. Because labor is perfectly mobile between sectors, the agricultural wage rate and the non-agricultural real wage rate are equal in equilibrium. As factors are paid their marginal products, profit maximization by firms in both sectors implies that $\theta_a = w_a N_a / p_a Y_a$ and $\theta_m = w_m N_m / p_m Y_m$. Since $w_a = w_m$ and capital shares are the same across countries, it follows that relative productivity in each country is just the ratio of the capital shares, i.e.,

$$\frac{p_a Y_a / N_a}{Y_m / N_m} = \frac{\theta_m}{\theta_a}. \tag{6}$$

Policy distortions, therefore, have no effect on relative productivity. The straightforward agricultural extension of the neo-classical growth model cannot account for the sectoral relative productivity differences observed across countries.

The failure of the model suggests a number of possible alternative theories. One such alternative in the spirit of Caselli and Coleman (2001) is to allow for factors that impede the movement of labor from agriculture into manufacturing. Some countries do heavily restrict movement out of rural areas. We do not follow this approach. Instead, we consider an extension of the neoclassical growth model that allows for home production activities that differ between rural and urban sectors.

As noted earlier, the assumption of Cobb–Douglas production functions is important to this analytic result. This raises the issue of to what extent one could generate the observed differences in relative productivities by having a different production function. Perhaps not surprisingly, it is possible to account for some of the observed differences in relative productivities by moving to a different specification of technology in the agricultural sector. Intuitively, if a poor country has less capital and labor and capital are more substitutable in agriculture than in non-agriculture, then as the amount of capital decreases the capital to labor ratio may fall more in agriculture than in non-agriculture, thereby leading to a lower average product of labor in agriculture. While we do not present the details here, calculations that we performed showed that with an elasticity of substitution between capital and labor in agriculture of two (rather than one for the case of Cobb–Douglas), we could plausibly account for one half of the differences in relative productivities between the richest and poorest countries given the observed differences in capital. We conclude that theoretically there is scope for such an explanation to play a role, though as mentioned earlier, empirical work supports the assumption of a unitary elasticity of substitution.

5. The model with agriculture and home production

In this section, we add a home production sector to the growth model with agriculture and examine whether it can account for the US secular growth facts and the sectoral development facts. The key feature of our abstraction is to allow for spatial heterogeneity

[12] To examine whether the model can account for the sectoral transformation undergone by the rich countries, one would need to calibrate the model. The performance of this model along this dimension is discussed in the next section.

and have a rural region that is more conducive to home production opportunities than the urban region. With no loss in generality, we focus on policy differences that lead to differences in the cost of investment goods relative to consumption goods rather than differences in TFP. As shown by Parente and Prescott (2000), there is a one-to-one mapping from this type of distortion to TFP.

5.1. Model economy

The critical aspect of our formulation is that we incorporate spatial heterogeneity by having an urban region and a rural region. Agriculture takes place exclusively in the rural region, whereas manufacturing is assumed to take place exclusively in the urban region.[13] Individuals living in both regions are assumed to have access to home production technologies that differ across regions.

To simplify the analysis, we assume that the economy is populated with a continuum of identical infinitely lived families, with each family consisting of a continuum of family members. Families, rather than individual family members, own the economy's capital. This assumption buys us considerable simplicity since we do not have to keep track of the heterogeneity in capital holdings associated with differences in location. A family member lives either in the rural area, in which case he divides his time between the home sector and the agricultural sector, or in the urban area, in which case he divides his time between the home sector and the manufacturing sector. A family head makes all the family decisions—how many family members live in each region, how they allocate their time between market and home production, how much consumption each receives and how much capital to accumulate. In keeping with the analysis of the previous section, we continue to assume perfect mobility of individuals across locations.

For reasons of space, we describe only those aspects of the model economy that are associated with the introduction of home production and spatial heterogeneity. Preferences are the same as before and given by Eq. (1). However, non-agriculture consumption, C_t, is now a CES aggregator of the manufacturing good c_{mt}, and the home good, c_{ht},

$$C_t = \left[\mu c_{mt}^{\rho} + (1-\mu) c_{ht}^{\rho}\right]^{1/\rho}. \tag{7}$$

In (7), the parameter μ reflects the relative importance of the home and market non-agriculture goods and the parameter ρ determines the elasticity of substitution between home-produced and market-produced goods.

With the introduction of home production, the capital endowment includes rural home capital and urban home capital denoted by K_{R0}, and K_{U0}. Each individual family member is still endowed with one unit of time each period. Individuals must divide their time between market and home production in each period. For workers located in the rural region this constraint is written $n_{at} + n_{Rt} = 1$, while for workers located in the urban region it is written $n_{mt} + n_{Ut} = 1$.

[13] Of course this is a stylization. In reality, a considerable amount of non-agricultural market production takes place in rural areas. Moreover, urban agriculture (e.g., poultry and swine) may be important in some locations. Nonetheless, the stylization is convenient here.

The technologies for the manufacturing and agricultural sectors are as before. With the addition of home production in the spatial model, there are two home production technologies,

$$Y_{jt} = A_j K_{jt}^{\alpha}\left[(1+\gamma)^t N_{jt}\right]^{1-\alpha}, \tag{8}$$

where K_{jt} is capital, and N_{jt} is hours in home production in region $j = U, R$. An important feature of our specification is that we assume that home production opportunities are "better" in the rural sector than in the urban sector. There are various ways this could be modeled; we choose to incorporate this feature by assuming that the two home production technologies are identical except for a difference in TFP. Specifically, we assume that $A_R > A_U$.[14]

Investment in home capital, like investment in market capital, requires forgoing consumption of the manufactured good. The laws of motion for the home capital stocks are:

$$K_{Rt+1} = (1-\delta)K_{Rt} + X_{Rt}, \tag{9}$$

$$K_{Ut+1} = (1-\delta)K_{Ut} + X_{Ut}. \tag{10}$$

As is apparent, home capital is assumed to depreciate at the same rate as market capital, but the policy distortions do not affect home capital. Relaxing these assumptions do not have a large impact on our findings, but in any case we view this as a reasonable benchmark.

The family head's objective is to maximize the discounted value of average utility across family members. Let λ_t denote the fraction of the representative family living in the urban region at date t. Additionally, let $U(c_{mt}^j, c_{ht}^j, a_t^j)$ denote the period utility of a family member who lives in region j and receives the date t consumption allocation $(c_{mt}^j, c_{ht}^j, a_t^j)$. The problem of the head of the representative family is to choose a sequence $\{(a_t^j, c_{mt}^j, c_{ht}^j)_{j=U,R}, K_{mt+1}, K_{at+1}, K_{Ut+1}, K_{Rt+1}, n_{mt}, n_{at}, n_{Ut}, n_{Rt}, \lambda_t\}_{t=0}^{\infty}$ that maximizes:

$$\sum_{t=0}^{\infty} \beta^t \left[\lambda_t U\left(c_{mt}^U, c_{ht}^U, a_t^U\right) + (1-\lambda_t) U\left(c_{mt}^R, c_{ht}^R, a_t^R\right)\right] \tag{11}$$

subject to:

$$\sum_{t=0}^{\infty} P_t\Big[\lambda_t\left(c_{mt}^U + p_{at}a_t^U\right) + (1-\lambda_t)\left(c_{mt}^R + p_{at}a_t^R\right) - \pi_m K_{mt+1} - \pi_a K_{at+1} - K_{Ut+1} - K_{Rt+1}\Big]$$

[14] Alternatives include assuming that the rural home production function is less capital intensive than the urban home production function, or that there are complementarities in time inputs between agricultural activities and home production, or that there are better substitution possibilities between home and market goods in rural areas. For example, child care may be more easily supplied while working in rural areas than in urban areas, and services such as food processing and distribution are accomplished via home production in rural areas, and via market production in urban areas.

$$\leqslant \sum_{t=0}^{\infty} P_t\big[w_{mt}\lambda_t n_{mt} + r_{mt}K_{mt} + (1-\lambda_t)w_{at}n_{At} + r_{at}K_{At} + (1-\delta)(\pi_m K_{mt} + \pi_a K_{at} + K_{Rt} + K_{Ut})\big], \tag{12}$$

$$n_{at} + n_{Rt} = 1, \tag{13}$$

$$n_{mt} + n_{Ut} = 1, \tag{14}$$

$$\lambda_t c_{ht}^U \leqslant A_U K_{Ut}^{\alpha_u}\big[(1+\gamma)^t \lambda_t n_{Ut}\big]^{1-\alpha_u}, \tag{15}$$

$$(1-\lambda_t)c_{ht}^R \leqslant A_R K_{Rt}^{\alpha_R}\big[(1+\gamma)^t(1-\lambda_t)n_{Rt}\big]^{1-\alpha_R}, \tag{16}$$

given initial capital stocks.[15] Equation (12) is the family's intertemporal budget constraint, where P_t is the Arrow–Debreu date 0 price of the manufacturing good at date t. Equations (13) and (14) are the time use constraints of individual family members living in the rural and urban regions. Equation (15) states that home consumption of rural family members is less than or equal to the total home production produced in that region. Equation (16) is the analogous constraint for the urban population.

In our abstraction there are two features that distinguish home production from manufacturing sector output. First, capital can only be produced in the manufacturing sector. One possible variation is to assume that home capital can be produced in the home sector, though we have not explored it. Second, home produced output cannot be traded. In some instances we think of this as a defining characteristic of home production—e.g., child care is home produced only if the family provides it for itself. In other cases, this assumption is probably not appropriate—for example, clothing made at home by family members in the rural area may be sent to family members in the city. While our assumption is extreme, what is important for our results is that a significant component of home production cannot easily be transferred across regions.

5.2. *Quantitative findings*

In this section we examine the quantitative properties of the model in order to determine whether it can account for the sectoral differences observed across countries and across time within a given country. We proceed by first restricting the model's parameters so that its equilibrium path over a 120-year period roughly matches the US economy's path over the 1870–1990 period. For this parameterized economy, we then examine how policy distortions affect the model's predictions for differences across countries in aggregate income and sectoral patterns of production.

5.2.1. *Calibration*

There are three aspects of the model that make the calibration procedure non-standard. The first is that capital is interpreted broadly to include intangible capital. Because investments in intangible capital are not measured in the national accounts, there is

[15] The fact that the family chooses the division of individuals between the urban and rural areas means that this problem is not concave. However, it can still be shown that the solution to this problem is characterized by the usual first order conditions. See Rogerson (1984) for a proof in a similar context.

a discrepancy between output in the model and output in the *National Income and Product Accounts* (NIPA). This necessitates that we adjust output in the model by the amount of this unmeasured investment in order to make comparisons with the NIPA data. (See Parente and Prescott, 2000 for an extended discussion.)

The second aspect of the model that makes the calibration non-standard is the subsistence term in the utility function. This term implies that we can no longer view the US economy as if it were on a constant growth path, as is the case in the one sector version of the model described in Section 3. In this version, the economy will only approach a constant growth path equilibrium as the effect of the subsistence term becomes infinitesimally small, or equivalently, as agriculture's share of GDP approaches a constant. In reality, this share has declined rather substantially over the postwar period, suggesting that the postwar period should not be viewed as a constant growth path. In terms of the calibration, this means that the parameter values must be restricted to match this decline. It follows that we cannot assign the technology growth rate parameter γ to be the average growth rate of US GDP per capita over the postwar period. However, we can still require that the model match the growth rate of US GDP per capita over some interval. While this match is not solely determined by the value of γ, it will be heavily influenced by it.

The third aspect that makes the calibration non-standard is home production. Home production is unmeasured in the NIPA. The stock of household durables can be used as a rough estimate for the total stock of home capital. However, there is no way to determine how much of this is allocated between rural households and urban households. This lack of measurement implies that it will not be possible to restrict all the values of the home production preference and technology parameters with the use of data. Some assumptions will have to be made to restrict a number of these parameter values. For this reason, the calibration should be viewed as somewhat exploratory in nature.

The basic strategy of the calibration is to use observations from the US time series to restrict all the preference and technology parameters not related to home production. The one exception is the value of the capital share in manufacturing. For this we exploit the estimate of intangible capital's share from Parente and Prescott (2000). For the home production parameters, our strategy is to use information on the stock of household durables in the United States, market hours data for individuals outside of agriculture, and estimates for the elasticity of substitution between market and home goods by Rupert et al. (1995) and McGrattan et al. (1997).

The empirical counterparts of the model are as follows. Total (measured) investment in market capital is the sum of residential and non-residential investment expenditures plus 25 percent of government expenditures. The remaining part of government expenditures is considered to be consumption. The value of agricultural output is the value of output of the farm sector, and the value of (measured) nonagricultural output is GDP less the value of farm output. The source of these statistics is the *1991 Economic Report of the President*, Tables B1, B8, and B32 and the US Commerce Department's *Historical Statistics of the United States* (1975), Series F 251. Agricultural capital is simply non-residential farm capital. Measured non-agricultural physical capital is simply total capital minus agricultural capital. The source of the capital stock data is Musgrave (1993, Tables 2 and 4). The empirical counterparts relevant for home production are the 1990 stock of household durables, and the fraction of discretionary time spent in market work for individuals outside the agricultural sector. We note that the empirical counterparts of the residences of both farmers and non-farmers are included as part of the manufactured capital stock, rather than as part of household capital.

A final issue in the calibration is the choice of values for initial capital stocks. Rather than attempt to obtain estimates of capital stocks for 1870, we choose these values so the implied series for investment and sectoral labor shares do not display any abrupt changes in the periods following 1870. Loosely speaking, the idea is to choose capital stocks for 1870 that would be consistent with the economy being on a transition path that began some years earlier.[16]

Table 1 reports the parameter values and provides comments on how each value was chosen. Note that $\gamma = 0.0198$, which is slightly lower than the 2 percent average growth rate over 1960–1990 that we targeted in our calibration. This is because the growth rate during this period is still slightly higher than its value on the constant growth path. Nonetheless, the behavior of the calibrated model in the post World War II period is very similar to a constant growth equilibrium; the capital to output ratios, the investment to output ratio, and the growth rate of real GDP are all nearly constant. As a final comment, our procedure for allocating the two-thirds share for total capital in the nonagricultural sector yields a split of 0.19 for tangible capital and 0.48 for intangible capital.[17] This implies that in 1990, investment in intangible capital is around one-half of measured GDP, which is in line with the estimates suggested by Parente and Prescott (2000).[18]

5.2.2. Properties of the calibrated model

5.2.2.1. The United States, 1870–1990. At this stage, it is informative to examine some of the long run properties of the calibrated model and compare them with their counterparts in the data. As we calibrate the model to reproduce the beginning and ending values for agriculture's share of GDP in the United States, we trivially match these observations. However, with respect to the rate of decline in agriculture's share of GDP, the model matches the US experience reasonably well with the exception of some large swings about trend in the 1890–1930 period.

We did not explicitly calibrate to match agriculture's share of employment, in either 1870 or 1990. In the United States in 1870, agriculture's share of employment is larger than its share of output. The calibrated model also displays this property, though the difference is not as large as in the data. Specifically, the model predicts an employment share of 36 percent in 1870 versus the value of 48 percent found in the data (US Department of Commerce, 1975).[19] The 48 percent share found in the data most surely overestimates agriculture's share of employment in 1870 as there are a large number of part time workers

[16] Given that our model is in discrete time, this procedure really only restricts initial capital stocks to lie in some interval. However, since the different values in this interval do not have any effect on the equilibrium beyond a few periods this does not appear to be a serious issue.

[17] This split is relevant because of the need to do the GNP accounts excluding intangible investments.

[18] Note that we assume intangible capital only in the manufacturing sector. We discuss the importance of this later in the paper.

[19] The calibrated non-home production model studied in Section 4 actually performs worse along this dimension.

Table 1
Parameter values

Parameters	Value	Comments
θ_m Capital share in manufacturing	0.667	Based on estimates from Parente and Prescott (2000) for market production with tangible and intangible capital.
θ_a Capital share in agriculture	0.240	Consistent with 1990 agricultural capital stock and output, and average annual rate of interest over postwar period.
A_m TFP in manufacturing	1.00	Normalization that only affects units in which output is measured.
A_a TFP in agriculture	1.00	Normalization that only affects level of relative prices.
π_m Barrier in manufacturing	1.00	Normalization for same reasons above.
π_a Barrier in agriculture	1.00	Normalization for same reasons above.
γ Exogenous rate of technological change	0.198	Consistent with average annual growth rate of US over postwar period of 2 percent
δ Depreciation rate	0.063	Consistent with 1990 investment and capital stock data.
β Discount factor	0.960	Consistent with average annual interest rate of 6.5 percent over postwar period.
ϕ Expenditure share	0.003	1990 agriculture's share of output of 2.3 percent.
$\bar{a}$ Subsistence term	0.393	1870 agriculture's share of output of 22 percent.
A_R TFP in rural home production	1.00	Normalization that only affects units in which home good is measured.
A_U TFP in urban home production	0.900	Assumption that home production in urban area is less efficient compared to rural area by 10 percent.
α Capital share in home production	0.110	Consistent with stock of household durables and market work outside of agriculture in 1990.
μ Share parameter between market and home goods	0.362	Consistent with stock of household durables and market work outside of agriculture in 1990.
ρ Elasticity of substitution between market and home goods	0.400	Based on micro estimates of Rupert et al. (1995) and McGrattan et al. (1997) for United States.

in US agriculture, and these workers are not distinguished from full time workers in constructing employment measures. In light of this, the discrepancy between the model and the data along this dimension is not as bad as it appears.

Next we turn to the model's predictions for the behavior of relative sectoral productivities and prices over time. The model predicts that the ratio of average labor productivity in the two sectors is very nearly constant and equal to one. For the United States, this ratio was roughly constant only after 1920 and closer to two. This is not particularly disconcerting, since as documented earlier, the work by Alston and Hatton (1991) suggests that the data overstate the true differences in 1920. For relative prices, the changes over the 120-year period are quite small. In particular, the relative price of agriculture in the model is effectively constant, changing by roughly 1 percent over the 120-year period. This accords well with the data (see, e.g., Kongsamut et al., 1997). Additionally, the real rate of return for the calibrated economy shows this same small decline, decreasing from 7.5 to 6.5 percent over the 120-year period.

The model has rich predictions for time allocations. Not surprisingly, given our assumptions about home production possibilities, we find that individuals in the rural region devote more of their time to home production than do workers in the urban region. More interesting, our model predicts a decline in the fraction of time that an individual spends in market work over the 120-year period. The decline in the workweek in manufacturing is more than 10 percent, and virtually all of it takes place between 1870 and 1960. Hence, this model can account for a large part of the secular decline in the workweek in manufacturing. In the agricultural sector the decline is even larger: the workweek falls by almost 25 percent. Coincident with this secular decrease in time devoted to market work, there is a large movement of workers from the rural to the urban region.

5.2.2.2. Cross-country comparisons. How does the introduction of home production possibilities affect the model's predictions for sectoral differences across rich and poor countries? We now use this model to examine the implications of distortionary policies on the development process. To do this we contrast the behavior of our calibrated economy with no distortions to another economy with barriers, $\pi_a \geqslant 1$ and $\pi_m \geqslant 1$. As above, we assume that initial capital stocks in the distorted economy are such that the equilibrium paths for other variables display no abrupt changes over the 120-year period.

We have studied three cases. The first assumes that the distortions apply equally to both capital stocks and result in a fourfold increase in the cost of both types of capital relative to the undistorted economy (i.e., $\pi_m = \pi_a = 4$). The second assumes that distortions only apply to the manufacturing capital stock (i.e., $\pi_m = 4, \pi_a = 1$). The third case assumes that distortions only apply to the agriculture capital stock (i.e., $\pi_m = 1, \pi_a = 4$). Table 2 reports our results. For expositional purposes, we report only the results from the benchmark economy, (i.e., $\pi_m = \pi_a = 1$), and the case with $\pi_m = \pi_a = 4$. The reason for this is that the results for the $\pi_m = 1$ and $\pi_a = 4$ case are practically identical to the benchmark case, and the results for the $\pi_m = 4$ and $\pi_a = 1$ case are practically identical to the $\pi_m = \pi_a = 4$ case.

Table 2 reports NIPA GDP per capita, agriculture's share of GDP, agriculture's share of employment, relative productivity, time allocated to agriculture work in the rural sector, and time allocated to market work in the manufacturing sector at various dates across the undistorted and distorted economies. We note that our measure of relative productivity is chosen to correspond to the concept used in the data. Specifically, it looks at output per worker and not output per unit of labor input. Additionally, we note that GDP is calculated by using a geometric average of the 1990 price of agriculture in the two economies.

As the table shows, the model with home production generates differences in GDP per capita as observed in the data. The difference in GDP per capita associated with a barrier of 4 is approximately the factor 30 observed across the richest and poorest countries. The model also predicts sizeable differences in the share of employment accounted for by agriculture across rich and poor countries in 1990. In the undistorted economy, agriculture's share of employment is 5 percent in 1990, while in the distorted economy its share is 63 percent. Third, the model generates large cross-country differences in sectoral relative productivity. Relative productivity of the agricultural sector in the model is almost six times larger in the undistorted economy than it is in the distorted economy in 1990.

Table 2
International comparisons

	GDP		$p_a Y_a/\text{GDP}$		$1-\lambda$		y_m/y_a		n_a		n_m	
	$\pi=1$	$\pi=4$	$\pi=1$	$\pi=4$	$\pi=1$	$\pi=4$	$\pi=1$	$\pi=4$	$\pi=1$	$\pi=4$	$\pi=1$	$\pi=4$
1870	1.00	0.12	0.22	0.68	0.36	0.83	1.90	2.32	0.58	0.68	0.64	0.70
1900	1.92	0.14	0.13	0.49	0.22	0.74	2.03	2.97	0.52	0.42	0.60	0.51
1930	3.91	0.18	0.07	0.32	0.14	0.67	2.13	4.36	0.48	0.26	0.57	0.43
1960	7.31	0.27	0.04	0.19	0.08	0.63	2.20	7.36	0.46	0.16	0.55	0.40
1990	13.4	0.41	0.02	0.12	0.05	0.63	2.26	12.9	0.44	0.09	0.55	0.39

This is also very close to the difference between the richest and poorest countries in the 1990 cross section.

The reason the model generates these large differences in relative productivity is that there are large differences in time allocations of rural workers in 1990 across the rich (undistorted) and poor (distorted) economies. Rural workers in the poor economy are working only about 20 percent as much in market activity as their counterparts in a rich economy. Differences in time allocations in the urban region are much less pronounced. This asymmetry between the distortions on rural and urban time allocations is due to the asymmetry of home production opportunities across rural and urban regions.

As can be seen in the table, relative productivity differentials across distorted and undistorted countries increase over time. This phenomenon is driven by the secular change in time allocations of workers in the two regions. In the distorted economy the secular decline in the (market) workweek in the rural region is much larger than in the undistorted economy. Initially, although the distorted economy has more workers in the rural region, workers in the distorted economy have roughly the same time allocations as workers in the undistorted economy. This is because the subsistence constraint is relatively binding. Over time, this constraint eases and the time allocation in the rural area becomes increasingly distorted toward home production. Although the table stops in 1990 it is worth noting that the time allocation of rural workers to market production in subsequent years in the distorted economy continues to show a decline, although at a slower rate than over the 1870–1990 period. In the undistorted economy, in contrast, there is no subsequent decline. As a result, the relative productivity differentials continue to widen. Moreover, these differentials begin to reflect real output differences in agriculture.

The one dimension of the data on which the performance of the model is rather disappointing is agriculture's share of output across rich and poor countries. The differences predicted by the model are small relative to what is found in the data. One reason why the differences in agriculture's share of output implied by the model are so small is that individuals living in the rural region in the distorted economy allocate a small fraction of their time to market activities. A second reason is that the relative price of agriculture is lower in the poorer country, by roughly 80 percent. Alternative specifications for preferences may give rise to smaller effects on relative prices and help the model on this dimension. Accounting for the large difference in agriculture's share of GDP across rich and poor countries is a matter for future work.

A rather surprising result is that measured output in the distorted economy grows at a much slower rate than in the undistorted economy over the 120-year period, implying that relative GDPs diverge for a long time. In fact, as the table documents, it is not until roughly the end of the sample period that the distorted economy displays a growth rate of real GDP that is roughly equal to the exogenous growth rate of technology. This pattern is not generated in the other models studied in this paper. It is, however, the pattern observed in the data. With the start of the Industrial Revolution in England, disparities in living standards between the world's rich and poor countries began to increase. These disparities continued to increase until 1950. Our research shows that one does not need to assume differential rates of exogenous technological change or poverty traps to account for this pattern. Instead, a two-sector version of the neoclassical growth model with home production, a broad concept of capital, and a subsistence term can qualitatively generate this pattern. We conclude that this model may be very useful in accounting for the divergence in international incomes from the Industrial Revolution to the latter half of the twentieth century.

5.2.3. Sensitivity

One key feature of our abstraction is that TFP is lower in urban home production than in rural home production. In the numerical experiments, this was represented by a 10 percent productivity gap in the two home production technologies. Given the arbitrary nature of this parameterization, it is worthwhile to examine the sensitivity of the model's results to changes in this parameter value. We, therefore, consider alternative values of 0.85, 0.95 and 1.00 for A_U. In each case we recalibrate the model as discussed previously and compute the equilibrium path for 120 years. In the interest of space we only report statistics for 1990 rather than the entire time series.

Table 3 presents the results. Several features are worth noting. Starting with the case with no relative productivity differences, we observe that the model still predicts large differences in income across the two economies. However, it no longer predicts large differences in relative sectoral productivities between rich and poor countries. As A_U is decreased several patterns emerge. First, the difference in income per capita increases. Second, the difference in the share of the population living in the rural area increases. And third, the difference in relative sectoral productivities also increases. The table also indicates that the difference in agriculture's share of GDP also increases, but this effect is fairly modest. The qualitative patterns in this table are intuitive given the mechanics of the model discussed earlier. We conclude from this that the model predictions that we are emphasizing require relatively small productivity differences.

Table 3
Sensitivity of results (1990 comparisons)

A_U	GDP		p_aY_a/GDP		$1-\lambda$		y_m/y_a		n_a		n_m	
	$\pi=1$	$\pi=4$	$\pi=1$	$\pi=4$	$\pi=1$	$\pi=4$	$\pi=1$	$\pi=4$	$\pi=1$	$\pi=4$	$\pi=1$	$\pi=4$
0.85	13.3	0.36	0.02	0.13	0.06	0.72	2.9	17.5	0.37	0.08	0.55	0.44
0.90	13.4	0.41	0.02	0.12	0.05	0.63	2.3	12.9	0.44	0.09	0.55	0.39
0.95	13.2	0.46	0.02	0.11	0.04	0.43	1.9	6.5	0.50	0.13	0.55	0.31
1.00	13.2	0.53	0.02	0.11	0.04	0.19	1.6	1.9	0.55	0.27	0.55	0.25

A second issue noted earlier was our assumption that intangible capital is only relevant in the manufacturing sector. This assumption is quantitatively significant. As is well known, the impact of a given barrier on cross-country income differences is increasing in the capital share. Moreover, the impact of home production is increasing in the difference between the capital share in the home sector and the market sector. We have also analyzed a version of the model in which we abstract from intangible capital completely and assume a capital share of 0.30 in the manufacturing sector. Not surprisingly, in this case the factor difference in aggregate output as of 1990 is 2.25 rather than 30, and the factor differences in relative productivities is 1.7 rather than 5. Obviously, as is true in all models of this sort, with a smaller capital share one needs larger distortions to match the differences found in the data. The key point here is that we get a sizeable elasticity of relative productivities with respect to changes in aggregate income even with the smaller capital share.

5.2.4. Welfare comparison

As discussed and analyzed in Parente et al. (2000), home production models imply that differences in measured income across countries overstate the true differences in well-being. For our calibrated model, we note that in 1990, the undistorted economy consumes roughly 33 times more of the manufactured consumption good than does the distorted economy, 1.1 times more of the agricultural good, but only about two-thirds as much home produced output. In what follows we use our model to give a more precise measure of actual welfare differences and contrast them to those obtained in the standard growth model described in Section 3. We note that our measure is not affected by monotone transformations of the utility function.[20]

For the standard growth model, we assume a parameterization that roughly accords with the values used in Section 5. The barrier π is selected so that the factor difference in relative steady state incomes in this model equals the factor difference of 33 we obtained in our benchmark specification for 1990. Given a capital share equal to $2/3$, the corresponding value of π is 5.75. We compute the welfare gain associated with removing the barrier for this economy as follows. First, we compute the equilibrium path that would result if an economy beginning in the steady state corresponding to $\pi = 5.75$ were to eliminate this barrier. Next, we compute the utility of the representative agent associated with this equilibrium path. We then compute the utility of the representative agent if the economy does not eliminate this barrier and it remains in the steady state corresponding to $\pi = 5.75$. We then determine the factor by which we would have to increase consumption in each period under this second scenario in order that the resulting lifetime utility equal that achieved when the barrier were removed. This factor increase in consumption is our welfare measure.

The number we obtain is 2.8; i.e., if consumption were to be increased by a factor of 2.8 the individual would be indifferent about removing the barrier. Note that this number is small in comparison to the differences in steady state consumptions. The ratio of the two consumptions across the two steady states is 33—the same as the ratio of the two outputs. The fact that our compensating differential is so much smaller than this factor indicates

[20] Note that we have also assumed that there is unmeasured investment in the economy. This will not matter for our welfare calculations since they are based on consumption flows.

the importance of allowing for the accumulation of capital needed to reach the new steady state.

We now repeat this calculation in the context of our two-sector growth model with home production. Because there is no steady state for this economy, we take the 1990 allocations in the distorted economy as our stating point in the exercise. In determining the factor by which consumption would have to be increased in each period, we assume the consumption of the home good, manufacturing good, and agricultural good of all family members is increased proportionately. The number we obtain is 1.9, which is about two-thirds of the number we obtained in the welfare calculation for standard model. We conclude from this that while home production does diminish the welfare differences between rich and poor countries for a given difference in measured output, the reduction is not particularly large.

6. Conclusion

Development economists have long noted the importance of agriculture in the share of economic activity in poor countries. Contemporary researchers working with applied general equilibrium models almost always abstract from sectoral issues. In this paper, we introduced agriculture into the neoclassical growth model and examined the implications for international incomes and sectoral patterns. We found that a straightforward extension of the model fails to account for key sectoral differences observed across rich and poor countries. This failure led us to consider an extension of the model that incorporates home production. The key implication of this model is that distortions to capital accumulation lead to a relative increase in the amount of unmeasured activity taking place in rural areas. A reduction of the distortions leads to an efficiency-enhancing reallocation of inputs plus an increase in measured economic activity. We found the model accounts for a number of features of the sectoral transformation observed in economic data, both in the cross section and the time series.

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References

Alston, L., Hatton, T., 1991. The earnings gap between agricultural and manufacturing laborers, 1925–41. Journal of Economic History 51 (March), 83–99.

Bautista, R., Valdés, A., 1993. The Bias Against Agriculture: Trade and Macroeconomic Policies in Developing Countries. International Center for Economic Growth and the International Food Policy Research Institute, San Francisco, with ICS Press.

Caselli, F., Coleman II, J.W., 2001. The US structural transformation and regional convergence: a reinterpretation. Journal of Political Economy 109 (3), 584–616.

Chari, V.V., Kehoe, P., McGrattan, E. 1996. The poverty of nations: a quantitative exploration. Working paper 5414. NBER.

Chenery, H.B., Syrquin, M., 1975. Patterns of Development, 1950–1970. Oxford Univ. Press, London.

Collins, W., Williamson, J. 1999. Capital goods prices, global capital markets and accumulation: 1870–1950. Working paper No. 7145. NBER.

Echevvaria, C., 1995. Agricultural development vs. industrialization: effects of trade. Canadian Journal of Economics 28 (3), 631–647.

Echevarria, C., 1997. Changes in sectoral composition associated with economic growth. International Economic Review 38 (2), 431–452.

Fei, J.C.H., Ranis, G., 1964. Development of the Labor Surplus Economy: Theory and Policy. Richard D. Irwin, Homewood, IL. A publication of the Economic Growth Center, Yale University.

Glomm, G., 1992. A model of growth and migration. Canadian Journal of Economics 42 (4), 901–922.

Goodfriend, M., McDermott, J., 1995. Early development. American Economics Review 85 (1), 901–922.

Hall, R.E., Jones, C.I., 1999. Why do some countries produce so much more output per worker than others? Quarterly Journal of Economics 114 (1), 83–116.

Hayami, Y., Ruttan, V.W., 1985. Agricultural Development: An International Perspective. Johns Hopkins Univ. Press, Baltimore.

Inada, K., 1963. On a two-sector model of economic growth: comments and a generalization. Review of Economic Studies 30 (June), 95–104.

Johnston, B.F., Mellor, J.W., 1961. The role of agriculture in economic development. American Economic Review 51 (4), 566–593.

Johnston, B.F., Kilby, P., 1975. Agriculture and Structural Transformation: Economic Strategies in Late-Developing Countries. Oxford Univ. Press, New York.

Jones, C.I., 1994. Economic growth and the relative price of capital. Journal of Monetary Economics 34, 359–382.

Kongsamut, P., Rebelo, S., Xie, D., 1997. Beyond balanced growth. Review of Economic Studies 68 (4), 869–882.

Krueger, A.O., Schiff, M., Valdés, A., 1992. The Political Economy of Agricultural Pricing Policy, vols. I–III. A World Bank, Baltimore. Comparative study. Published for the World Bank by Johns Hopkins Univ. Press.

Kurian, G.T., 1994. Datapedia of the United States 1790–2000: America Year by Year. Bernan Press, Lanham, MD.

Kuznets, S., 1966. Modern Economic Growth. Yale Univ. Press, New Haven.

Kuznets, S., 1971. Economic Growth of Nations. Harvard Univ. Press, Cambridge, MA.

Laitner, J., 2000. Structural change and economic growth. Review of Economic Studies 67, 545–561.

Lewis, A., 1955. Theory of Economic Growth. Allen Unwin, London.

Maddison, A., 1995. Monitoring the World Economy: 1820–1992. Development Centre of the OECD, Paris.

Matsuyama, K., 1992. Agricultural productivity, comparative advantage, and economic growth. Journal of Economic Theory 58 (2), 317–334.

McGrattan, E., Rogerson, R., Wright, R., 1997. An equilibrium model of the business cycle with household production and fiscal policy. International Economic Review 38, 267–290.

Mellor, J.W., 1986. Agriculture on the road to industrialization. In: Lewis, J.P., Kallab, V. (Eds.), Development Studies Reconsidered. Overseas Development Council, Washington, DC.

Mitchell, B.R., 1992. International Historical Statistics: Europe 1750–1988. Stockton Press, New York.

Mitchell, B.R., 1993. International Historical Statistics: The Americas 1750–1988. Stockton Press, New York.

Mitchell, B.R., 1995. International Historical Statistics: Africa, Asia & Oceania 1750–1988. Stockton Press, New York.

Musgrave, J., 1993. Fixed reproducible tangible wealth in the United States: Revised estimates for 1990–92 and summary estimates for 1925–92. Survey of Current Business (September), 61–69.

Parente, S., Prescott, E.C., 1994. Barriers to technology adoption and development. Journal of Political Economy 102 (2), 298–321.

Parente, S., Prescott, E.C., 2000. Barriers to Riches. MIT Press, Cambridge.

Parente, S.L., Rogerson, R., Wright, R., 2000. Homework in development economics: home production and the wealth of nations. Journal of Political Economy 108, 680–687.

Prescott, E.C., 1998. Needed: a theory of total factor productivity. International Economic Review 39 (3), 525–551.

Rao, P., 1993. Intercountry comparisons of agricultural output and productivity. Paper 112. FAO Economic and Social Development, Rome. Food and Agriculture Organization of the United Nations.

Restuccia, D., Urrutia, C., 2001. Relative prices and investment rates. Journal of Monetary Economics 47, 93–122.

Rogerson, R., 1984. Topics in the theory of labor markets. Unpublished PhD dissertation. Univ. of Minnesota.

Rupert, P., Rogerson, R., Wright, R., 1995. Estimating substitution elasticities in household production models. Economic Theory 6 (1), 179–193.

Schiff, M., Valdés, A., 1992. The Political Economy of Agricultural Pricing Policy, vol. 4: A Synthesis of the Economics in Developing Countries. A World Bank, Baltimore. Comparative study. Published for the World Bank by Johns Hopkins Univ. Press.

Schultz, T.W., 1964. Transforming Traditional Agriculture. Yale Univ. Press, New Haven.

Syrquin, M., 1988. Patterns of structural change. Chapter 7 in: Chenery, H., Srinivasan, T.N. (Eds.), Handbook of Development Economics, vol. I. Elsevier Science, Amsterdam.

Takayama, A., 1963. On a two-sector model of economic growth: a comparative static analysis. Review of Economic Studies 30, 95–104.

Timmer, C.P., 1988. The agricultural transformation. Chapter 8 in: Chenery, H., Srinivasan, T.N. (Eds.), Handbook of Development Economics, vol. I. Elsevier Science, Amsterdam.

US Department of Commerce, 1975. Historical Statistics of the United States: Colonial Times to 1970. US Bureau of the Census, Washington, DC.

Uzawa, H., 1961. On a two-sector model of economic growth: I. Review of Economic Studies 29, 40–47.

Uzawa, H., 1963. On a two-sector model of economic growth: II. Review of Economic Studies 30, 105–118.